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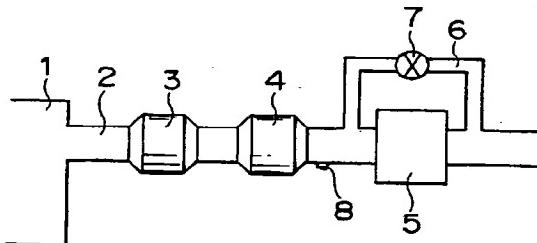
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(54) Exhaust emission control device and method for controlling an exhaust emission of an internal combustion engine

(57) To reduce the amount of fuel consumption required for the combustion of particulates that have been trapped in a filter (4), an exhaust emission control device of the present invention includes the filter (4) disposed in an engine exhaust passage (2) to trap particulates, a hydrocarbon adsorbent (3) disposed upstream of the filter (4) in the engine exhaust passage (2), exhaust gas resistance change means (5, 6, 7) disposed downstream of the hydrocarbon adsorbent (3) in the engine exhaust passage (2), and an operating means for operating the exhaust gas resistance change means (5, 6, 7) to increase a resistance against exhaust gas.

FIG. 1



DescriptionINCORPORATION BY REFERENCE

[0001] The disclosure of Japanese Patent Application No. HEI 9-206864 filed on July 31, 1997 including the specification, drawings and abstract is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION1. Field of the Invention

[0002] The present invention relates to an exhaust emission control device for an internal combustion engine and, more specifically, to an exhaust emission control device that has a filter for trapping particulates disposed in an exhaust passage of an internal combustion engine and causes the trapped particulates to burn so that the filter is regenerated.

2. Description of the Related Art

[0003] Exhaust gas discharged from a diesel engine contains a relatively large amount of fine particles (particulates) including carbon as a major constituent, which causes serious contamination of the environment. It is therefore desirable to inhibit the generation of such particulates in the engine or to remove the particulates prior to the discharge of the exhaust gas into the atmosphere. For this purpose, it is proposed that a filter for trapping particulates be disposed in an exhaust passage of a diesel engine.

[0004] In the case where a filter for trapping particulates is disposed in an exhaust passage of a diesel engine, if the amount of particulates trapped in the filter increases, there is caused an increase in a flow resistance against exhaust gas, which leads to a deterioration in engine performance. Thus, it is necessary to cause the particulates trapped in the filter to burn on the regular basis and to regenerate the filter.

[0005] For example, if the engine operates at such a high speed that the exhaust gas temperature exceeds about 600°C, it is possible to cause the particulates trapped in the filter to spontaneously burn. However, the engine does not operate in such a state on the regular basis. According to JP-A-56-18016, a filter carries an oxidation catalyst for causing fuel to burn on the regular basis, so that the combustion heat generated at this time causes particulates to burn.

[0006] The aforementioned related art requires additional fuel to be directly supplied to the oxidation catalyst. If the engine is used over a long period of time, an enormous amount of additional fuel is supplied to the oxidation catalyst.

SUMMARY OF THE INVENTION

[0007] It is thus an object of the present invention to provide an exhaust emission control device and a method for controlling an exhaust emission such that the amount of fuel to be supplied to an oxidation catalyst is reduced to cause particulates trapped in a filter to burn.

[0008] This object is solved by the features of the independent claims 1 and 7. The dependent claims disclose further advantageous embodiments of the invention.

[0009] An exhaust emission control device of the present invention comprises a filter disposed in an engine exhaust passage to trap particulates, a hydrocarbon adsorbent disposed upstream of the filter in the engine exhaust passage, exhaust gas resistance change means disposed downstream of the hydrocarbon adsorbent in the engine exhaust passage, and an operating means for operating the exhaust gas resistance change means to increase a flow resistance against exhaust gas. Corresponding features are present in the method claim. Thus, the atmospheric pressure of the hydrocarbon adsorbent is enhanced throughout the engine operation and the difference in maximum adsorption amount for a certain temperature difference increases, whereby it is possible to discharge a large amount of hydrocarbon from the hydrocarbon adsorbent. As a result, it is possible to reduce the amount of fuel consumption required to cause particulates trapped in the filter to burn.

[0010] The exhaust emission control device of the present invention may be modified such that the exhaust gas resistance change means comprises a turbine of a turbocharger disposed downstream of the filter in the engine exhaust passage, a bypass passage for bypassing the turbine, and a control valve disposed in the bypass passage, and that the operating means closes the control valve. Thus, the exhaust energy exceeding the energy that has been lost due to an increase in a flow resistance against exhaust gas is regenerated by the turbocharger. Therefore, it is possible to reduce the amount of fuel consumption required to cause particulates trapped in the filter to desirably burn.

[0011] The exhaust emission control device of the present invention may further have the operating means to operate the exhaust gas resistance change means to reduce a resistance against exhaust gas when the filter is at a temperature higher than a first predetermined temperature. To ensure that the exhaust gas resistance change means operates to reduce a resistance against exhaust gas when the exhaust gas temperature is higher than the first predetermined temperature, when the hydrocarbon discharged from the hydrocarbon adsorbent effectively contributes to the combustion of particulates, the maximum adsorption amount of hydrocarbon is reduced. It is thus possible to further discharge a large amount of hydrocarbon. When the

exhaust gas temperature is lower than the first predetermined temperature and the hydrocarbon discharged from the hydrocarbon adsorbent does not effectively contribute to the combustion of particulates, the maximum adsorption amount of hydrocarbon is increased to inhibit the discharge of hydrocarbon. It is thus possible to reserve a certain amount of hydrocarbon in preparation for the time when the hydrocarbon effectively contributes to the combustion of particulates. In this manner, it is possible to effectively use the unburnt fuel contained in exhaust gas for the combustion of particulates.

[0012] The exhaust emission control device of the present invention may further be modified such that the operating means operates the exhaust gas resistance change means to reduce a flow resistance against exhaust gas when the exhaust gas temperature is higher than the first predetermined temperature at the time of engine deceleration. The operation of the exhaust gas resistance change means for reducing a flow resistance against exhaust gas, which is accompanied by fluctuations in engine outputs, is performed at the time of engine deceleration. It is thus possible to halt a deterioration in drivability and to cause particulates to desirably burn at the time of engine deceleration when exhaust gas contains a high concentration of oxygen.

[0013] The exhaust emission control device of the present invention may still further be provided with prohibition means for prohibiting the operating means from reducing the flow resistance of the exhaust gas resistance change means when the exhaust gas temperature is higher than a second predetermined temperature that is higher than the first predetermined temperature. When the exhaust gas temperature is higher than the second predetermined temperature and the particulates desirably burn, the maximum adsorption amount is reduced to prevent hydrocarbon from being further discharged. It is thus possible to effectively use the unburnt fuel contained in exhaust gas for the combustion of particulates and to prevent the filter from melting through excessive heating.

[0014] This summary of the invention does not necessarily describe all necessary features so that the invention may also reside in a sub-combination of these described features.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The object as well as features and advantages of the present invention will become apparent from or are described in the following description of the preferred embodiments with reference to the accompanying drawings, wherein:

Fig. 1 is a schematic view of an exhaust emission control device for an internal combustion engines according to a first embodiment of the present invention;

Fig. 2 is a graph showing a relationship between the maximum adsorption amount and the atmospheric pressure of a hydrocarbon adsorbent;

Fig. 3 is a graph showing a relationship between the particulate combustion amount and the filter temperature;

Fig. 4 is a flowchart for controlling a waste gate valve;

Fig. 5 is a time chart showing changes in atmospheric pressure of the hydrocarbon adsorbent during engine acceleration and engine deceleration; and

Fig. 6 is a schematic view of an exhaust emission control device for an internal combustion engines according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0016] Preferred embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

[0017] Fig. 1 schematically shows an exhaust emission control device for an internal combustion engine according to a first embodiment of the present invention. Referring to Fig. 1, reference numerals 1 and 2 denote a diesel engine body and an engine exhaust passage, respectively. The engine exhaust passage 2 is provided with a hydrocarbon trap 3. A filter 4 for trapping particulates is disposed downstream of the hydrocarbon trap 3 and a turbine 5 of a turbocharger is disposed downstream of the filter 4. The exhaust passage 2 is connected with a waste gate passage 6 for bypassing the turbine 5. Disposed inside the waste gate passage 6 is a waste gate valve 7 for controlling the amount of exhaust gas bypassing the turbine 5. A temperature sensor 8 detects an exhaust gas temperature immediately downstream of the filter 4.

[0018] The hydrocarbon trap 3 contains a hydrocarbon adsorbent that reliably adsorbs hydrocarbons such as mordenite, Y-zeolite, X-zeolite, ZSM-5 and the like. The filter 4 has, for example, a partition wall made of a porous substance, a metallic fiber nonwoven fabric or the like and is designed to trap particulates when exhaust gas radially flows through the partition wall. The filter 4 carries an oxidation catalyst.

[0019] It is true that the aforementioned hydrocarbon adsorbent adsorbs hydrocarbon as an unburnt substance contained in exhaust gas, but there is a certain limit as to the amount of hydrocarbon to be adsorbed. The maximum adsorption amount of the adsorbent depends on temperature and atmospheric pressure thereof. Fig. 2 shows a relationship between the maximum adsorption amount V and the atmospheric pressure P of the hydrocarbon adsorbent separately for the case where the hydrocarbon adsorbent is at a first temperature $Tt1$ and for the case where the hydrocarbon

adsorbent is at a second temperature T_{t2} ($T_{t2} > T_{t1}$). As can be seen from the curves in Fig. 2, the lower the atmospheric pressure P of the hydrocarbon adsorbent becomes, the less the maximum adsorption amount V becomes. Furthermore, the higher the temperature of the hydrocarbon adsorbent becomes, the less the maximum adsorption amount V becomes.

[0020] In the case where the hydrocarbon adsorbent changes in temperature from the first temperature T_{t1} to the second temperature T_{t2} , the amount of hydrocarbon discharged from the hydrocarbon adsorbent corresponds to a difference in maximum adsorption amount between those temperatures T_{t1} and T_{t2} . For example, the curves in Fig. 2 reveal that the amount of hydrocarbon discharged is $\Delta V_1(V_{t1}-V_{t2})$ under a high atmospheric pressure of P_4 and $\Delta V_2(V_{t1}-V_{t2})$ under a low atmospheric pressure of P_1 . The higher the atmospheric pressure becomes, the more hydrocarbon is discharged. In the present embodiment, the turbine 5 of the turbocharger is disposed downstream of the hydrocarbon trap 3 of the engine exhaust passage 2 and the waste gate valve 7 is normally closed. Thus, the turbine 5 constitutes a flow resistance against exhaust gas that allows a substantial increase in atmospheric pressure of the hydrocarbon adsorbent throughout the engine operation. For a certain change in temperature of the hydrocarbon adsorbent, such a flow resistance against exhaust gas brings about an increase in the amount of hydrocarbon discharged.

[0021] In the present embodiment as described hitherto, it is possible to discharge a comparatively large amount of hydrocarbon from the hydrocarbon adsorbent upon a change in temperature thereof, after the oxidation catalyst carried by the filter 4 has been activated due to a relatively high exhaust gas temperature (about 200°C). Accordingly, the oxidation catalyst carried by the filter 4 allows desirable combustion of the hydrocarbon thus discharged, and the particulates trapped in the filter burn due to the combustion heat generated at this time. In this manner, the filter can be regenerated without necessitating additional fuel.

[0022] If the oxidation catalyst is activated, the hydrocarbon discharged from the hydrocarbon adsorbent burns and the combustion heat generated at this time contributes to the combustion of particulates, whereby the regeneration of the filter is started. Thus, if a higher combustion heat is generated upon start of the regeneration of the filter by further discharging a large amount of hydrocarbon from the hydrocarbon adsorbent, it is possible to cause particulates to burn more desirably. For this purpose, it is considered to open the waste gate valve 7 and to thereby reduce a flow resistance against exhaust gas. Thus, the atmospheric pressure of the hydrocarbon adsorbent decreases, whereby it is possible to further discharge a large amount of hydrocarbon (e.g. $\Delta V_3(V_{t1}-V_{t2})$ in Fig. 2). The opening operation of the waste gate valve 7 results in a decrease in boost pressure of the turbocharger, and thus a decrease in

engine outputs. Therefore, it is desirable that the waste gate valve 7 be opened at the time of engine deceleration. When the engine decelerates, fuel supply is temporarily suspended or at least the amount of fuel injection is significantly reduced. In this state, there is a large amount of oxygen contained in exhaust gas, which is quite advantageous in terms of the combustion of particulates.

[0023] Fig. 3 is a graph showing a relationship between the particulate combustion amount B and the temperature T_f of the filter 4. As is apparent from this graph, when the filter temperature is higher than a predetermined temperature T_{f1} , the particulate combustion amount per unit of a rise in temperature substantially increases. The amount of unburnt fuel contained in exhaust gas is relatively small and the hydrocarbon adsorbent does not invariably adsorb a maximum amount of hydrocarbon. The unburnt fuel contained in the exhaust gas efficiently contributes to the combustion of particulates in the following manner. That is, when the filter temperature is lower than the predetermined temperature T_{f1} , the hydrocarbon adsorbent prevents hydrocarbon from being discharged therefrom, and when the filter temperature is higher than the predetermined temperature T_{f1} , the hydrocarbon adsorbent discharges a large amount of hydrocarbon.

[0024] Fig. 4 is a flowchart of a waste gate valve control for performing such an operation. The routine of this flowchart is repeated at predetermined time intervals. 30 First in step 101, it is determined whether or not the amount of change in accelerator pedal depression stroke ΔTA , which is detected by an accelerator pedal stroke sensor (not shown), is larger than a predetermined value A . If the determination in step 101 gives the affirmative result, the engine is in a state of acceleration and the operation proceeds to step 102.

[0025] In step 102, it is determined whether or not the exhaust gas temperature detected by the temperature sensor 8 is higher than a first temperature T_1 . The exhaust gas is at the first temperature T_1 (e.g. about 400°C) immediately downstream of the filter 4, when the filter temperature assumes the predetermined temperature T_{f1} . If the determination in step 102 gives the negative result, the operation proceeds to step 105, where a flag F is set to 0 to terminate the operation. On the other hand, if the determination in step 102 gives the affirmative result, the operation proceeds to step 103, where it is determined whether or not the exhaust gas temperature T is higher than a second temperature T_2 . The exhaust gas is at the second temperature T_2 (e.g. about 700°C) immediately downstream of the filter 4, when the filter 4 is at a sufficiently high temperature and the particulates are in a desirable state of combustion. If the determination in step 103 gives the affirmative result, the operation proceeds to step 105, where the flag F is set to 0 to terminate the operation. If the determination in step 103 gives the negative result, the operation proceeds to step 104, where the flag F is set to 1

to terminate the operation.

[0026] If the determination in step 101 gives the negative result after completion of engine acceleration, the operation proceeds to step 106, where it is determined whether or not the amount of change in accelerator pedal depression stroke ΔTA is smaller than a predetermined value (-A). If the determination in step 106 gives the negative result, the engine is in a steady state and the operation is terminated. On the other hand, if the determination in step 106 gives the affirmative result, the engine is in a state of deceleration and the operation proceeds to step 107.

[0027] In step 107, it is determined whether or not the flag F is set to 1. If the determination in step 107 gives the negative result, the operation is terminated with the waste gate valve 7 remaining closed. However, if the flag F has been set to 1 at the time of engine acceleration, the operation proceeds to step 108, where the waste gate valve 7 is opened.

[0028] Fig. 5 is a time chart showing changes in the atmospheric pressure P of the hydrocarbon adsorbent caused by such a control operation of the waste gate valve. In this time chart, the engine that is in a predetermined steady state sequentially undergoes acceleration and deceleration and finally returns to the predetermined steady state. To make it easy to understand the specific features of the present invention, the temperatures and atmospheric pressures of the hydrocarbon adsorbent are determined as follows. The hydrocarbon adsorbent is at the first temperature Tt1 as shown in Fig. 2 prior to acceleration and it is heated to the second temperature Tt2 as shown in Fig. 2 after acceleration. Even after deceleration, the hydrocarbon adsorbent is maintained at the second temperature Tt2. The atmospheric pressure of the hydrocarbon adsorbent in the predetermined steady state with the waste gate valve 7 being closed assumes the third atmospheric pressure P3 as shown in Fig. 2. The atmospheric pressure of the hydrocarbon adsorbent with the waste gate valve 7 being opened assumes the second atmospheric pressure P2 as shown in Fig. 2.

[0029] During engine acceleration, the amount of exhaust gas increases. Upon termination of engine acceleration, the pressure upstream of the turbine 5 of the turbocharger, i.e. the atmospheric pressure P of the hydrocarbon adsorbent increases to the fourth atmospheric pressure P4, which is higher than the third atmospheric pressure P3. Unless the exhaust gas temperature immediately downstream of the filter 4 exceeds the first temperature T1 during engine acceleration, the flag F is set to 0, so that the waste gate valve 7 remains closed at the time of engine deceleration. Thus, after engine deceleration, the atmospheric pressure P decreases to the third atmospheric pressure P3, as is indicated by a solid line in Fig. 5. Therefore, the maximum adsorption amount of the hydrocarbon adsorbent assumes V32 as indicated in Fig. 2. In this state, even if the filter 4 is supplied with hydrocarbon, the hydrocar-

bon does not efficiently contribute to the combustion of particulates. Thus, the hydrocarbon adsorbent is designed to adsorb a relatively large amount of hydrocarbon, i.e. no less than the maximum adsorption amount V32 of hydrocarbon. If the amount of hydrocarbon adsorbed by the hydrocarbon adsorbent is still below the maximum adsorption amount V32, it is possible to desirably adsorb hydrocarbon during a steady-state operation that is subsequently performed.

[0030] On the other hand, if the exhaust gas temperature immediately downstream of the filter 4 exceeds the first temperature Tt1 during engine acceleration, the flag F is set to 1 and the waste gate valve 7 is opened at the time of engine deceleration. Thus, at the time of engine deceleration, as is indicated by a broken line in Fig. 5, the atmospheric pressure P decreases to the second atmospheric pressure P2 and the maximum adsorption amount of the hydrocarbon adsorbent decreases to V22 as is shown in Fig. 2. If the filter 4 is supplied with hydrocarbon at this time, the hydrocarbon efficiently contributes to the combustion of particulates. Hence, the hydrocarbon adsorbent adsorbs a relatively small amount of hydrocarbon, i.e. no more than the maximum adsorption amount V22 of hydrocarbon. The hydrocarbon adsorbent discharges a large amount of hydrocarbon that has so far been adsorbed. In this manner, a relatively small amount of unburnt fuel contained in exhaust gas can be effectively used for the combustion of particulates, so that the filter 4 can be regenerated without necessitating additional fuel.

[0031] If the exhaust gas temperature immediately downstream of the filter 4 exceeds the second temperature Tt2 at the time of engine acceleration, the combustion of particulates is spontaneously started because of a high temperature of exhaust gas or because of a combustion heat of the hydrocarbon discharged due to a rise in temperature of the hydrocarbon adsorbent at this time, so that there is no need to further discharge hydrocarbon. Thus, at the time of engine deceleration, the waste gate valve 7 remains closed and the hydrocarbon adsorbent adsorbs a relatively large amount of hydrocarbon, i.e. the maximum adsorption amount V32 of hydrocarbon. Hence, the wasteful use of the hydrocarbon adsorbed by the hydrocarbon adsorbent is avoided and the filter 4 is prevented from melting through excessive heating.

[0032] Fig. 6 schematically shows an exhaust emission control device for an internal combustion engine according to a second embodiment of the present invention. This exhaust emission control device is different from that of the first embodiment in that an exhaust throttle valve 9 is disposed downstream of the filter 4 instead of the turbine of the turbocharger and the waste gate passage. Even in a fully closed state, the exhaust throttle valve 9 allows passage of a certain amount of exhaust gas. By controlling the exhaust throttle valve 9 substantially in the same manner as the waste gate valve 7, it is possible to achieve substantially the same

effect as in the first embodiment. The turbine of the turbocharger also recovers part of the thermal energy of exhaust gas, so that the exhaust gas temperature downstream of the turbine decreases, which is disadvantageous in terms of the combustion of particulates. For this reason, the turbine cannot be disposed upstream of the filter 4. However, the exhaust throttle valve 9 does not exhibit such a disadvantage and therefore can be disposed at any location downstream of the hydrocarbon trap 3. It is not absolutely required that the exhaust throttle valve 9 be disposed downstream of the filter 4.

[0033] Although the aforementioned two embodiments relate to a diesel engine, the present invention can also be applied to a gasoline engine, whose exhaust gas also contains particulates. Furthermore, in the case where the amount of unburnt fuel contained in exhaust gas is comparatively small and the hydrocarbon discharged from the hydrocarbon adsorbent cannot sufficiently contribute to the combustion of particulates, it is considered to directly or indirectly supply the filter with fuel. Also in this case, the aforementioned unburnt fuel partially contributes to the combustion of particulates, whereby it is possible to significantly reduce the amount of additional fuel required.

[0034] While the present invention has been described with reference to what is presently considered to be preferred embodiments thereof, it is to be understood that the invention is not limited to the disclosed embodiments or constructions. On the contrary, the invention is intended to cover various modifications and equivalent arrangements falling within the scope of the claims. In addition, while the various elements of the disclosed invention are shown in various combinations and configurations, which are exemplarily, other combinations and configurations, including more, less or only a single embodiment, are also covered by the scope of the claims. It does not limit the claimed invention and that the discussed combination of features might not be absolutely necessary for the inventive solution.

[0035] To reduce the amount of fuel consumption required for the combustion of particulates that have been trapped in a filter (4), an exhaust emission control device of the present invention includes the filter (4) disposed in an engine exhaust passage (2) to trap particulates, a hydrocarbon adsorbent (3) disposed upstream of the filter (4) in the engine exhaust passage (2), exhaust gas resistance change means (5, 6, 7) disposed downstream of the hydrocarbon adsorbent (3) in the engine exhaust passage (2), and an operating means for operating the exhaust gas resistance change means (5, 6, 7) to increase a resistance against exhaust gas.

Claims

- #### **1. An exhaust emission control device for an internal**

combustion engine comprising a filter (4) disposed in an engine exhaust passage (2) to trap particulates, a hydrocarbon adsorbent (3) disposed upstream of the filter (4) in the engine exhaust passage (2), exhaust gas resistance change means (5, 6, 7; 9) disposed downstream of the hydrocarbon adsorbent (3) in the engine exhaust passage (2), and an operating means for operating the exhaust gas resistance change means (5, 6, 7; 9) to increase a flow resistance against the exhaust gas in dependency on predetermined operating conditions.

- 15 2. An exhaust emission control device according to
claim 1, characterised in that the operating means
operates the exhaust gas resistance change
means (5, 6, 7; 9) to increase the flow resistance or
to maintain the increased flow resistance at the
time of engine acceleration and further operates to
maintain the increased flow resistance of the
exhaust gas resistance change means (5, 6, 7; 9) at
the time of engine deceleration in dependency on
predetermined operating conditions.

20 25 3. An exhaust emission control device according to
claim 1 or 2, characterised in that the exhaust gas
resistance change means comprises a turbine (5)
of a turbocharger disposed downstream of the filter
(4) in the engine exhaust passage (2), a bypass
passage (6) for bypassing the turbine (5), and a
control valve (7) disposed in the bypass passage
(6) and that the operating means closes the control
valve (7) to increase the flow resistance.

30 35 4. An exhaust emission control device according to
claim 1, 2 or 3, characterised in that the operating
means operates the exhaust gas resistance
change means (5, 6, 7; 9) to reduce a flow resist-
ance against exhaust gas when the filter (4) is at a
40 temperature higher than a first predetermined tem-
perature.

45 5. An exhaust gas emission control device according
to claim 4, characterised in that the operating
means operates the exhaust gas resistance
change means (5, 6, 7; 9) to reduce a flow resist-
ance against exhaust gas when the exhaust gas
temperature (T) is higher than the first predeter-
mined temperature (T1) at the time of engine decel-
eration.

50 55 6. An exhaust gas emission control device according
to claim 4 or 5, characterised by prohibition means
for prohibiting the operating means from reducing
the flow resistance of the exhaust gas resistance
change means (5, 6, 7; 9) when the exhaust gas
temperature (T) is higher than a second predeter-
mined temperature (T2) that is higher than the first

predetermined temperature (T1).

7. A method for controlling an exhaust emission of an internal combustion engine comprising the steps of:

trapping particulates by a filter (4) disposed in an engine exhaust passage (2);

adsorbing hydrocarbons by a hydrocarbon adsorbent (3) disposed upstream of the filter (4) in the engine exhaust passage (2).

influencing a flow resistance against the exhaust gas by a exhaust gas resistance change means (5, 6, 7; 9) disposed downstream of the hydrocarbon adsorbent (3) in the engine exhaust passage (2) and

operating the exhaust gas resistance change means (5, 6, 7; 9) by an operating means to increase a flow resistance against the exhaust gas in dependency on predetermined operating conditions.

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FIG. 1

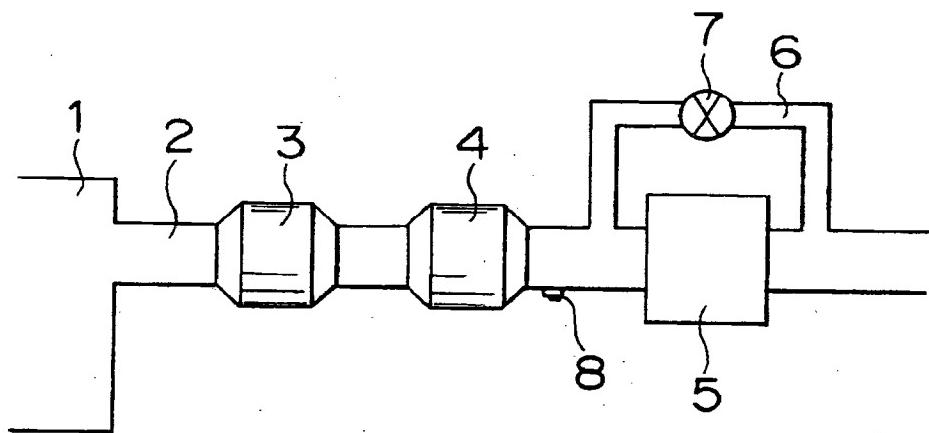


FIG. 2

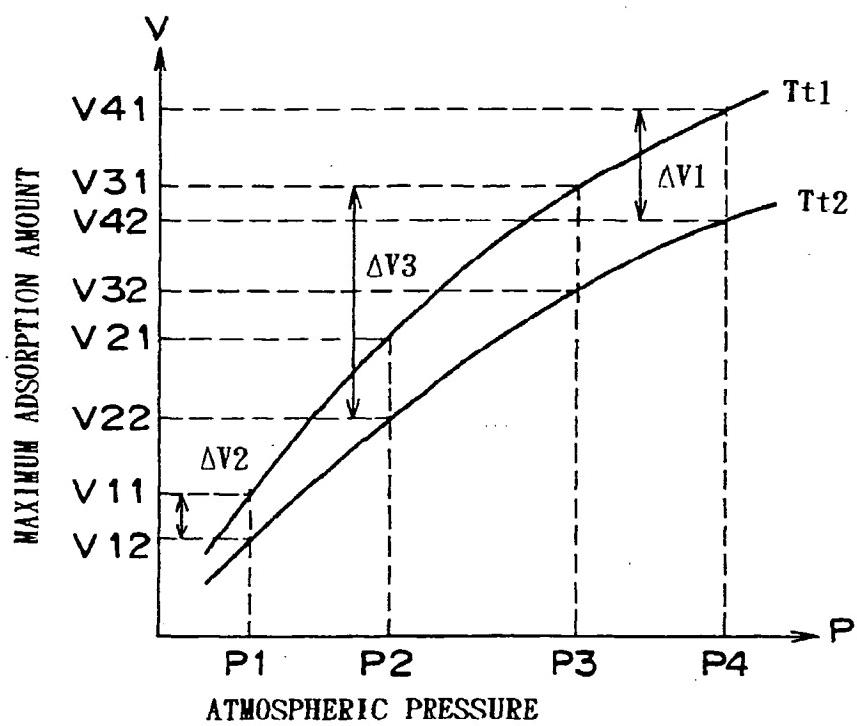


FIG. 3

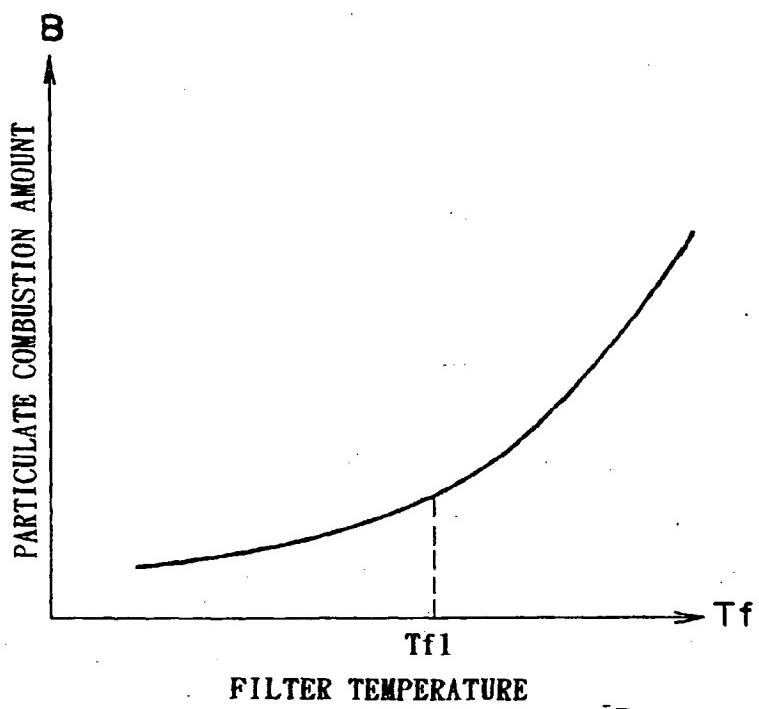


FIG. 4

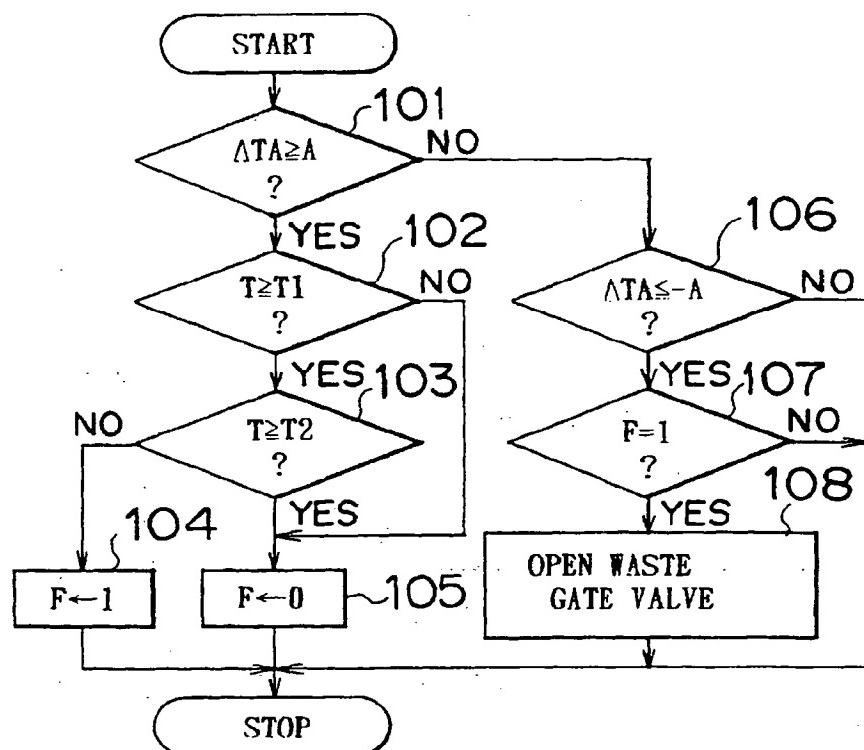


FIG. 5

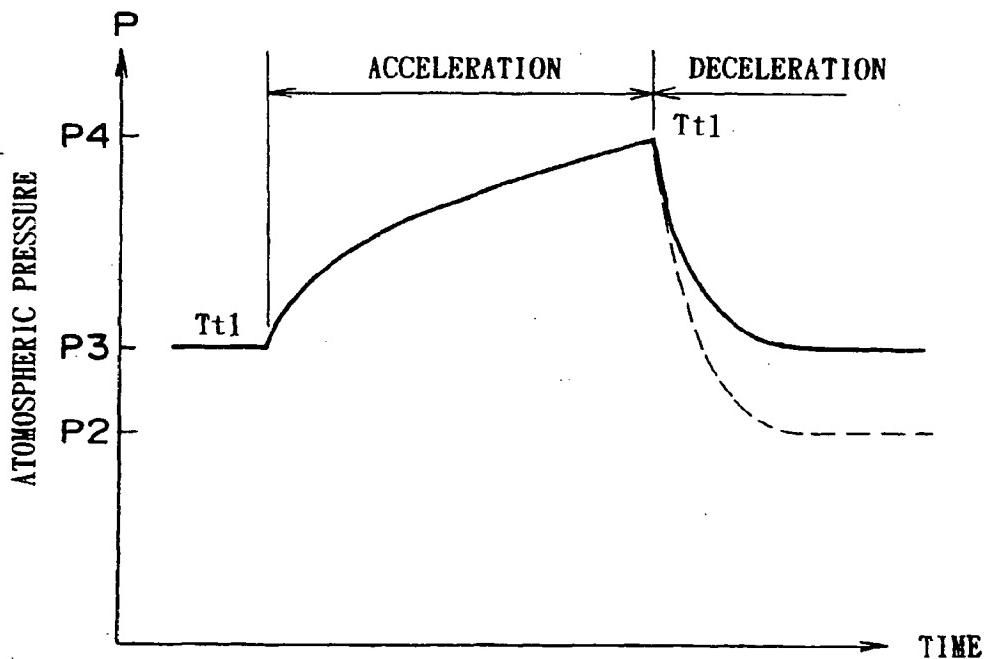
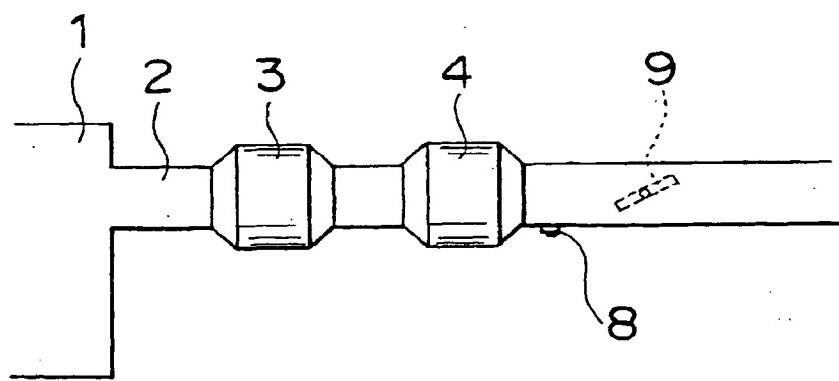


FIG. 6





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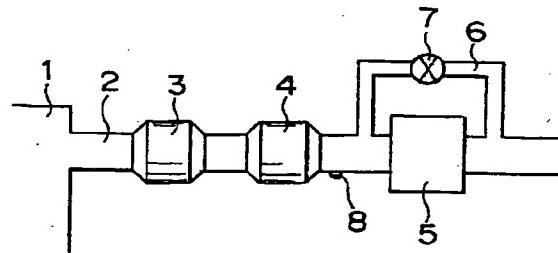
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FIG. 1





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 11 4312

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	EP 0 743 429 A (TOYOTA MOTOR CO. LTD) 20 November 1996 (1996-11-20) * column 8, line 41 - column 9, line 18; figure 8 *	1,7	F01N3/023 F01N3/08 F02B37/18 F01N3/035
A	US 4 553 387 A (MAYER ANDREAS) 19 November 1985 (1985-11-19) * column 6, line 14 - line 34; figures *	1,3,7	
A	DE 43 25 004 A (NORD KLAUS JUERGEN) 3 February 1994 (1994-02-03) * abstract; figures *	1,7	
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			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			F02B F01N
<p>The present search report has been drawn up for all claims</p>			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	14 March 2000	Sideris, M	
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